[redacted]

FACILITY FORM 602

N67-81904	
(ACCESSION NUMBER)	(THRU)
7	None
(PAGES)	(CODE)
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

[redacted]

GENERAL DYNAMICS

Convair Division

[redacted]

A2136-1 (REV. 5-65)

S/41985

REPORT NO. GDC-DDG66-006
DATE 19 March 1966
NO. OF PAGES 7+ii

GENERAL DYNAMICS | ASTRONAUTICS

MONTHLY PROGRESS REPORT
(Covering the period
20 February to 19 March 1966)

STUDY OF STABILITY OF UNPRESSURIZED SHELL STRUCTURES UNDER STATIC LOADING

Contract Number NAS8-11181
Request Number DCN 1-5-53-01067

Prepared for the
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REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED

A 700-1 (REV. 1-63)

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1.0 SUMMARY

This report constitutes the tenth informal monthly progress report submitted under contract NAS8-11181, "Study of Stability of Unpressurized Shell Structures Under Static Loading", and covers the period 20 February to 19 March 1966. A monthly Financial Report (NASA Form 533), presenting a summary of total and actual costs for the month of February, is being submitted under separate cover.

The major accomplishments within this reporting period were as follows:

1. Continued reduction of test data.
2. Essential completion of writing for Part I of the final report.

Several telephone conversations were held with the NASA Technical Representative (H. L. Billmayer) regarding the status of the study.

2.0 OVERALL PROGRESS

The major effort within this reporting period was devoted to writing of the final report. Part I of the report has been essentially completely written and is now being typed. Several changes were made in the tentative report outline furnished in the previous progress report. In particular, the format for Section 6 was changed to the following:

6. COMPRESSIVE BUCKLING OF LONGITUDINALLY STIFFENED CIRCULAR CYLINDERS

   6.1 General

   6.2 Buckling Criteria

6.2.1 Almroth Extension to Thielemann Solution

6.2.2 Stuhlman-DeLuzio-Almroth Solution

6.3 Computation of Fixity Factor For Longitudinally Stiffened Sections Between Rings.

6.4 Comparison Against Test Data

6.4.1 Longitudinally Stiffened Circular Cylinders

6.4.2 Fixity Factor For Longitudinally Stiffened Sections Between Rings.

Part I of the final report will be submitted for NASA approval as soon as typing is completed and reproductions are made. This should be accomplished about 1 April 1966.

Work was completed on the reduction of test data from reference 1 and comparison against the proposed prediction techniques. None of the specimens reported there incorporated any eccentricities. The results of this evaluation are given in Table I.

In addition, further work was accomplished to modify the computations previously made for the specimens of references 2 and 3. The modification consisted of incorporating (n') values different from unity in both the α and F determinations. Fully accounting for existing stringer eccentricities, the results shown in Table II were obtained.

TABLE I

COMPARISON OF PREDICTED CRITICAL STRESS VALUES AGAINST THE TEST RESULTS OF REF. 1

Specimen No.	$\frac{\text{Calculated } \sigma_{cr}}{\text{Test } \sigma_{cr}}$	Specimen No.	$\frac{\text{Calculated } \sigma_{cr}}{\text{Test } \sigma_{cr}}$
1	1.17	24	.99
2	1.03	25	.97
3	1.10	26	.98
4	1.02	27	1.01
5	1.20	28	1.07
6	1.21	29	1.18
7	.92	30	1.00
8	1.16	31	1.27
9	1.20	32	.97
10	1.12	33	1.08
11	1.04	34	1.00
12	.94	35	1.05
13	.96	36	1.00
14	1.08	37	.96
15	1.06	38	.95
16	1.02	39	.90
17	1.07	40	.93
18	1.06	41	1.08
19	.98	42	1.06
20	1.16	43	1.03
21	.99	44	.93
22	.94	45	.79
23	.94		

TABLE II

COMPARISON OF PREDICTED CRITICAL STRESS VALUES AGAINST THE TEST RESULTS OF REFS. 2 AND 3

Reference No.	Specimen No.	$\dfrac{\text{Calculated } \sigma_{cr}}{\text{Test } \sigma_{cr}}$
2	1	.90
2	2	.94
2	3	.80
2	4	.87
2	5	.75
2	6	.76
3	1	.70
3	2	.75
3	3	.72
3	4	.71
3	5	.93

The fixity factor approach proposed in reference 4 for the evaluation of effects of frames on panel instability strengths was compared with some available test data. It was found that only very limited applicable data were available but for the specimens investigated, quite satisfactory agreement was achieved.

Data on tests from reference 5 of two frame-stiffened corrugated cylinder configurations which failed in the panel instability mode were compared with predictions employing the method presented in the curves of reference 6 for determination of buckling stress and the method of reference 4 for determination of the fixity factor. Specifically, equation (2) of reference 6 was employed and for these specimens, because of their lack of circumferential stiffness, the third term was found to be negligible. A General Dynamics Convair digital computer program modified for the purpose was used to obtain frame stiffnesses to permit evaluation of the fixity factor in this equation.

One specimen from reference 7 which was reported to have failed in the panel instability mode was also analyzed. Prebuckling of the skin and high torsional stiffness of the frames (closed section) required slight modifications to the approach and a hand solution for an approximate frame torsional constant was accomplished. For this calculation, the rotational restraint afforded a stringer by the frame was determined primarily from the torsional stiffness of the frame between the two adjacent stringers.

Results from these three comparisons are shown in Table III.

TABLE III

COMPARISON OF PREDICTED CRITICAL STRESS VALUES EMPLOYING FIXITY FACTOR INFLUENCES

Reference No.	Specimen No.	Fixity Factor	$\frac{\text{Calculated } \sigma_{cr}}{\text{Test } \sigma_{cr}}$
4, Vol. I	7	1.01	1.02
4, Vol. I	8	1.01	.99
7	II-4	1.6	.97

Test data were also evaluated for the specimens of reference 5 which failed in the general instability mode. Analysis which neglects the influence of eccentricities has been completed. However, these results indicate that the eccentricity influences must be assessed. In order to allow adequate time for preparation of the final report, extension of this analysis was discontinued. Should the rate of progress on the final report make it possible, this extension will be resumed within the next reporting period. At the present time, it is thought that the most important task is to thoroughly and clearly document the study results to facilitate ready application of the proposed analysis methods.

3.0 PROBLEMS

Aside from the difficulty cited above, no serious problems, which might impede performance, have been encountered.

4.0 PLANS FOR NEXT PERIOD

It is planned that the next reporting period be devoted almost entirely to completion of the final report.

5.0 LIST OF REFERENCES

1. Cheatham, Joseph F., "Buckling Characteristics of Corrugated Cylinders", Part II - Summary, Watertown Arsenal Technical Report No. WAL TR 715/3-Pt.2, July 1960.

2. Peterson, J. P., and Dow, M. B., "Compression Tests on Circular Cylinders Stiffened Longitudinally by Closely Spaced Z-Section Stringers", NASA Memo 2-12-59L, March 1959.

3. Card, M. F., "Preliminary Results of Compression Tests on Cylinders With Eccentric Longitudinal Stiffeners", NASA TM X-1004, Sept. 1964.

4. Smith, G. W. and Dittoe, F. A.,"Monthly Progress Report Covering Period 20 August to 19 September 1965",Contract Number NAS8-11181, General Dynamics Convair Report GDC-DDG65-023, 19 September 1965.

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6. Smith, G. W. and Dittoe, F. A.,"Monthly Progress Report Covering Period 20 July to 19 August 1965",Contract Number NAS8-11181, General Dynamics Convair Report GDC-DDG65-021, 19 August 1965.

7. Card, M. F., "Bending Tests of Large-Diameter Stiffened Cylinders Susceptible to General Instability", NASA TN D-2200, April 1964.